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The Ant Community of a Riparian Forest in the Dyke Marsh Preserve, Fairfax County, Virginia, and a Checklist of Mid-Atlantic Formicidae

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ABSTRACT

The ant community of the Dyke Marsh Preserve forest, Fairfax County, Virginia, was sampled using pitfall traps and Berlese extraction of soil-core samples, yielding 3,193 ants of 27 species. Inclusion of an earlier study from this riparian forest adds four species. The Chao2 species estimator predicted 32 ant species in the study forest based on data from both studies. The ant species found in this study are common in the eastern U.S. and mid-Atlantic riparian forests with two exceptions: *Lasius subumbratus* is south of its previously known distribution on the U.S. East Coast, and *Vollenhovia emeryi* is an alien myrmicine native to Japan. *Aphaenogaster rudis*, *Paratrechina faisonensis*, and *Prenolepis imparis* were the more abundant ant species in samples in the forest. The intraspecific abundance of these species was similar across sampling years, but the intraspecific abundance of the less-abundant ant species was not similar from year to year. The results of this study show that this ant community is composed of many habitat-generalists and common species.

Key words: Dyke Marsh Preserve, Formicidae, riparian forest, species estimators, *Vollenhovia emeryi*.

INTRODUCTION

Ants provide important services in eastern U.S. forests such as dispersing seeds, controlling arthropod populations, turning over and adding nutrients to forest soils, and providing habitat and a food source for many other organisms (Hölldobler & Wilson, 1990). Scientists have studied the ants of the U.S. mid-Atlantic region in detail for many decades. Studies have investigated nest movement and myrmechory (Culver & Beattie, 1978; Beattie et al., 1979; Smallwood & Culver, 1979); ant community structure, interference, competition, and foraging patterns (Lynch et al., 1980; Lynch, 1981; Lynch et al., 1988; Fellers, 1987, 1989); and ant and habitat associations (Wang et al., 2000, 2001; Kjar & Barrows, 2004). Lynch (1987) produced a checklist and key to the ants of the Chesapeake Bay region. There are an estimated 129 ant species in the mid-Atlantic region occupying various habitats (Barrows & Kjar, 2005). However, published ant-species lists exist for only a small number of areas in the region.

The goals of this study were to (1) describe the ant community of the Dyke Marsh Preserve (DMP) forest and changes in the abundance and richness of ant species across multiple sampling months and years; and (2) compare the DMP ant community with other eastern U.S. ant communities and with a theoretical community composed of the more common species found in those studies and lists.

MATERIALS AND METHODS

Study Forest

Dyke Marsh Preserve is part of the George Washington Memorial Parkway (GWMP) in Fairfax County, Virginia (38° 46′ N, 77° 03′ W). The GWMP is a national park bordering the western shore of the Potomac River. The DMP is 3.5 km long, 500 m wide at its widest point on an east-west transect, and located 15 km south of the Ronald Reagan Washington National Airport. The DMP has areas of flood-plain forests, open tidal freshwater marsh, and swamp forests (Johnston, 2000; Barrows et al., 2005). All of my sampling sites are within the DMP forest, which I divided into an eastern and western part for analytical purposes. The western part of the study forest was frequently submerged during high tide and some areas may be designated as a swamp forest. The eastern forest is 1-2 m above sea level, had standing water only during floods, and may be considered a flood-plain forest, or low forest.

The study forest is dominated by *Liquidambar styraciflua* (Sweetgum) and a dense understory of *Lindera benzoin* (Spicebush) and *Viburnum molle* (Smooth Arrowwood). Other trees common in the forest include *Acer negundo* (Boxelder), *Acer rubrum* (Red Maple), *Fraxinus americana* (White Ash), *Liriodendron tulipifera* (Tulip Tree), *Nyssa sylvatica* (Tupelo), *Quercus palustris* (Pin Oak), *Quercus phellos* (Willow Oak), *Quercus rubra* (Red Oak), *Sassafras albidum* (Sassafras), and *Ulmus americana* (American Elm).

A plant survey of the sites used in this study found nine alien and 42 native forest-floor species (excluding trees over 1 m tall), and 16 tree species. Alien plants made up more than 40% of all plant cover. The most common alien plant, *Lonicera japonica,* was found in 80% of the sites used in this study.

Site Selection

I selected 100 random sites within the DMP study forest using a geographical information system (GIS) and high-resolution aerial photography with the cooperation of the National Park Service GIS coordinator of the GWMP. I used the computer program Arcview™ 3 (ESRI, 2001) and the National Park Service's AlaskaPak extension (National Park Service, 2002), which randomly selects any number of points within a polygon and creates a list of coordinates for each point. Sites were in a predefined area of the forest whose borders were at least 10 m from trails or roads. This area was bordered by the Mt. Vernon Trail on the west, Haul Road and the Potomac River on the east, a large tidal channel on the south, and an area overgrown with *Ampelopsis brevipedunculata* (Porcelainberry) vines on the north.

I used a Trimble™ backpack global positioning system (GPS) to locate each of the sites in the forest. Forty of the 100 sites were not appropriate for analysis due to their location near or in a tidal channel that floods during high tides. Sites were chosen if they were accessible, not waterlogged, and at least 3 m from any other site. The decision to keep or reject a site was made during a dry year and some sites that were initially kept in the study were later found to be waterlogged or have standing water during much of my sampling period. Such sites were excluded from some analyses.

Ant Collection and Identification

I collected a soil core (70-mm diameter by 70-mm deep) from each site in the third week of June, August, and October of 2002 and 2003. Arthropods were extracted from the soil in Berlese funnels with 5 mm mesh plastic screen and air dried for 5 days in a room under 24 h of fluorescent lighting. Artificial heat was not used during extraction because test runs of this method found unacceptable mortality of diplurans, symphylans, and other soft-bodied arthropods before extraction. Arthropods were collected into jars containing 95% ethanol as the killing fluid.

A single collar and funnel pitfall trap was used at each study site (Kjar & Barrows, 2004). A 120-mm-diameter plastic container with a lid was placed in the center of each site so that the lid was level with the surrounding ground level. All pitfall traps were in position 1 mo before trapping began to reduce the impact of trap placement on sampling.

For each trapping bout, all lids were removed, and a 120-ml collection cup containing 95% ethanol was placed in the bottom of the plastic container. A collar around the top of the pitfall trap supported a plastic funnel leading into the collection cup. Soil was then carefully spread on the collar up to the edge of the funnel. A wooden cover 32-cm^2 with four 4-cm-long legs was placed over the trap and wired to the ground using 20-cm-long coffin nails to protect the trap from animals, weather, and falling plant material. This pitfall-trap design results in a high arthropod per trap hour catch (Kjar, 2002) and prevents non-target vertebrates from injuring themselves or damaging the trap.

The pitfall traps were run for 24 h, in the last week of June, August, and October during 2002 and 2003. Arthropods from pitfalls and soil cores were sorted into appropriate taxonomic units (Borror et al., 1981) under a dissecting microscope.

Additional trapping data from a previous DMP study (Kjar, 2002) were used in some descriptions in this study. In that study, pitfall traps of an identical design were used in four 100-m^2 plots located in the DMP low forest. Each plot had 10 randomly placed pitfall traps making a total of 40 pitfalls. Trapping occurred during August-October of 2000, and June-October of 2001.

Ants were identified using Bolton (1994), Creighton (1950), the U.S. National Museum of Natural History ant collection, and verified by David R. Smith, and Terry P. Nuhn (both of the USDA). A voucher collection is located at the Laboratory of Entomology and Biodiversity, Georgetown University, Washington, D.C.

Data Analysis

I used the computer program EstimateS (Colwell, 2004) to calculate the species number estimator Chao2. Chao2 uses the number of singletons (species found once) and doubletons (species found twice) based on species absence or presence across all samples for each sampling event to formulate an estimate of the number of species that have not been detected during sampling (Chao, 1987; Colwell & Coddington, 1994; Coddington et al., 1996). This form of species estimation uses random resampling of sampling events to produce a mean species estimate for each cumulative sampling event. The data used in this study are the absence or presence of a species during a sampling event. Sampling events are the combined incidences of all soil-core samples, pitfall-trap samples, or both from a single month. There are eight sample events from 2000-2001, and six from 2002-2003.

Although trapping occurred in different areas of the study forest with some overlap among studies, the total number of pitfall-trap hours during each sampling event is the same for both pitfall-trap datasets alone, and the pitfall-trap design was the same as that used in the current study. Soil cores were not taken during the earlier study, and therefore, species estimators were used on both studies with and without soil-core data. For each sampling occasion, the number of samples in which an ant species was present was used as the species-incidence value rather than abundance data. Both incidence and abundance are used in this study since they both have value in describing an ant community.

Analysis of variance and the Student-Newman-Keuls *post hoc* test was used to determine significant differences in total ant species richness and abundance among months. The data used in ANOVA analysis included June, August, and September trapping dates from the 2000-2001 and 2002-2003 DMP studies. Mean monthly abundance and richness values were derived from all pitfall-trap samples collected during that month across all years.

I used coefficient of community similarity (CC) values to compare the similarity of the ant community of the DMP study forest with that of 15 other studies and lists from the eastern U.S., as well as the 31 ant species shared by the most studies and lists and the 31 ant species shared among those lists from the U.S. East Coast. This analysis will show whether the forest ant community of the DMP resembles the ant communities of urban forests, old forests, fields, or the most common ant species in this area. The coefficient of community similarity for each study or list was determined using the formula $CC = C_{ab}/(S_a+S_b)$, where S is the number of species in a study and C_{ab} is the number of species shared among studies. The species list of the DMP Area includes all ants captured in this study plus the ants caught in a previous study in the same forest (Kjar & Barrows, 2004).

I obtained information on feeding behavior, nesting sites, and habitats of the ant species found in this study from relevant literature (Talbot, 1934, 1943a, 1943b, 1945, 1946, 1951, 1965; Headley, 1943; Creighton, 1950; Nuhn & Wright, 1979; Deyrup & Trager, 1986; Deyrup et al., 1988; and others) and consulting myrmecologists (Stefan P. Cover, James P. Trager, Walter R. Tschinkel).

RESULTS

Ant Community

I obtained 3,193 ants from 27 species in pitfall traps and soil cores during this 2-yr study (Table 1). All 27 species were present in pitfall traps, and 15 were also present in soil cores. My study documented eight ant species not previously found at the DMP during an earlier 2-yr study (Kjar & Barrows, 2004). Furthermore, four species from the earlier study were not caught during this study: *Camponotus subbarbatus*, *Lasius claviger*, *Lasius subumbratus*, and *Myrmica emeryana* (Table 1). One species captured during this study, *Vollenhovia emeryi*, is newly recorded for Virginia, and is one of only four records of this ant in the U.S. (Kjar & Suman, 2007).

The more abundant ants in this study were *Aphaenogaster rudis*, *Paratrechina faisonensis*, and *Prenolepis imparis* (Table 1). Each of these species had more individuals captured than the abundances of all other ant species combined. These were also the more abundant species in the 2000-2001 study (Kjar & Barrows, 2004). Sample incidence, rather than abundance, shows that *A. rudis* is the most widespread species in this study (Table 2). Although *P. imparis* was more abundant in samples, it was found at fewer sites. This may be due to reduced foraging activity in *P. imparis* during warm summer months (Talbot 1943a; Lynch et al., 1980; Tschinkel, 1987; Fellers, 1989).

All native ant species caught during this and the previous study at the DMP are common forest ants except for *Solenopsis molesta* (Table 3). This species is commonly found in old fields or other open habitat (Headley, 1943), although it is occasionally found in forested areas in the mid-Atlantic region (Lynch, 1987).

Table 1. Ant species and their abundances in the forest pitfall-trap and soil-core samples, Dyke Marsh Preserve, Virginia. Species are ordered based on their total abundance in this study (2002-2003).

	2000-2001	2002-2003			2000-2003
Species	Pitfall traps	Pitfall traps	Soil cores	Both	Total
Aphaenogaster rudis	791	1012	4	1016	1807
Prenolepis imparis	1876	822	7	829	2705
Paratrichina faisonensis	780	463	254	717	1497
Pyramica rostrata	32	6	108	114	146
Lasius alienus	190	66	17	83	273
Myrmecina americana	34	12	65	77	111
Temnothorax curvispinosus	33	38	27	65	98
Ponera pennsylvanica	45	8	52	60	105
Tapinoma sessile		35	16	51	51
Stenamma brevicorne	42	26	9	35	77
Aphaenogaster fulva		28		28	28
Brachymyrmex depilis		1	26	27	27
Myrmica punctiventris	7	21		21	28
Camponotus chromaiodes		18		18	18
Pyramica ohioensis	5	3	10	13	18
Crematogaster cerasi	1	8		8	9
Lasius umbratus		1	6	7	7
Solenopsis molesta		5		5	5
Stenamma impar	10	3	1	4	14
Proceratium silaceum	1	1	2	3	4
Vollenhovia emeryi		3		3	3
Crematogaster pilosa	12	2		2	14
Camponotus pennsylvanicus	3	2		2	5
Aphaenogaster tennesseensis		2		2	2
Camponotus castaneus	4	1		1	5
Amblyopone pallipes	2	1		1	3
Camponotus nearcticus	2	1		1	3
Lasius claviger	3				3
Myrmica emeryana	3				3
Camponotus subbarbatus	2				2
Lasius subumbratus	1				1
Total species	23	27	15	27	31
Total abundance	3879	2589	604	3193	7072

The more abundant ant species found in pitfalls and soil cores tended to be non-specific in nest location (Table 3). The less abundant ant species (≤3 collected individuals) were predominately cavity-nesting species, and none of them commonly nest in forest litter (Table 3).

Comparison with Other Eastern U.S. Ant Surveys

The DMP ant community most closely resembles a hypothetical community comprised of the 31 most commonly reported species from regional species lists and studies (Table 4). The DMP ant community most closely resembles that found by King & Green (2005) in various urban forests around Philadelphia, Pennsylvania (Table 4). A study site in Illinois (Talbot, 1934) had the second closest ant community to that of DMP (Table 4). The study site least resembling the ant community at DMP was in West Virginia (Culver, 1974) and likely resulted from a limited sampling regime reporting only 17 species.

Of the 129 ant species that may be expected in the Washington, D.C., area, as described by Lynch (1987) and other studies and lists presented in Table 5, two common taxa were not found in DMP. The genus *Formica* was entirely absent and only one dolichoderine species was present, and that species, *Tapinoma sessile*, is common throughout temperate North America. Other genera with variable affinities for forest habitats which inhabit the mid-Atlantic region but were absent at DMP include most *Crematogaster* spp., most *Temnothorax* spp., all *Monomorium* spp.,

Table 2. Ant species found in the forest and their trap incidences, Dyke Marsh Preserve, Virginia. Species are ordered based on their total trap incidence in this study (2002-2003).

	2000-2001	2002-2003			2000-2003
Species	Pitfall traps	Pitfall traps	Soil cores	Both	Total
Aphaenogaster rudis	194	183	4	187	381
Paratrechina faisonensis	250	136	32	168	418
Prenolepis imparis	185	98	1	99	284
Lasius alienus	97	54	7	61	158
Ponera pennsylvanica	31	7	28	35	66
Tapinoma sessile		25	7	32	32
Temnothorax curvispinosus	27	22	6	28	55
Stenamma brevicorne	30	21	7	28	58
Myrmecina americana	32	8	17	25	57
Pyramica rostrata	20	3	18	21	41
Aphaenogaster fulva		13		13	13
Myrmica punctiventris	5	12		12	17
Crematogaster cerasi	1	8		8	9
Pyramica ohioensis	2	3	5	8	10
Brachymyrmex depilis		1	6	7	7
Campanotus chromaiodes		6		6	6
Stenamma impar	8	3	1	4	12
Proceratium silaceum	1	1	2	3	4
Vollenhovia emeryi		3		3	3
Aphaenogaster tennesseensis		2		2	2
Camponotus pennsylvanicus	3	2		2	5
Lasius umbratus		1	1	2	2
Solenopsis molesta		2		2	2
Amblyopone pallipes	2	1		1	3
Camponotus castaneus	4	1		1	5
Camponotus nearcticus	2	1		1	3
Crematogaster pilosa	8	1		1	9
Lasius claviger	3				3
Myrmica emeryana	3				3
Camponotus subarbatus	2				2
Lasius subumbratus	1				1

most *Myrmica* spp., and all *Pheidole* spp. (Table 5). Three ant species were shared among all studies: *A. rudis*, *Ponera pennsylvanica*, and *T. sessile*. *Lasius alienus* and *Temnothorax curvispinosus* were present in all but Talbot's (1965) study of a low old field in Michigan (Table 5). The only species present in DMP but absent from all other studies was *L. subumbratus*. *Vollenhovia emeryi* was listed in only one other study, and *Crematogaster pilosa* was found in two other studies. The remaining ant species found in DMP are common in the other studies and species lists (Table 5).

Ant Species Estimation

Using all incidence data from both Kjar & Barrows (2004) and this study, Chao2 species richness estimated 31.5 ant species in the DMP forest (Table 6). After 4 yr of trapping using two different trapping regimes, it is likely that most ant species present in the DMP study forest have been collected. Pitfall-trap sampling resulted in higher species estimates than soil-core sampling, and pitfall traps from the 2002-2003 study resulted in a higher species estimate after three sampling events than the entire eight sampling events of the 2000-2001 study.

Temporal Ant Distribution

Mean species richness was highest in August although this was not statistically significant (ANOVA, $F(2, 117) = 2.9$, $P = 0.06$; Fig. 1). Total ant abundance was lowest in June (ANOVA, $F(2, 117) = 2.9$, $P<0.001$; Fig. 1). Although the abundances of individual ant species were too low to analyze statistically, there were some patterns that are apparent from the 4 years of data. The psychrophile *P. imparis* was the most abundant ant during October (Fig. 2). *Aphaenogaster rudis* and *P. faisonensis* abundances decreased during both October 2002 and 2003 (Fig. 2). The common generalist ant *L. alienus* also decreased in

Table 3. Ant species nest location, feeding, and habitats, Dyke Marsh Preserve, Virginia.

	Nest location			Feeding behavior		Habitat		2000-2003
Species	Soil	Litter	Cavity*	Generalist	Specialist	Forest	Field	Abundance
Aphaenogaster rudis	x	x	x	x		x	x	1016
Prenolepis imparis	x			x		x	x	829
Paratrechina faisonensis		x	x	x		x		717
Pyramica rostrata		x			x	x		114
Lasius alienus	x	x	x	x		x	x	83
Myrmacina americana	x		x		x	x		77
Temnothorax curvispinosus			x	x		x		65
Ponera pennsylvanica	x		x	x		x	x	60
Tapinoma sessile	x	x	x	x		x	x	51
Stenamma brevicorne	x	x	x	x		x	x	35
Aphaenogaster fulva		x	x	x		x		28
Brachymyrmex depilis	x			x		x	x	27
Myrmica punctiventris	x		x	x		x	x	21
Camponotus chromaiodes			x	x		x		18
Pyramica ohioensis		x			x	x		13
Crematogaster cerasi	x	x	x	x		x	x	8
Lasius umbratus	x		x	x		x	x	7
Solenoposis molesta	x	x	x	x			x	5
Stenamma impar	x		x	x		x		4
Proceratium silaceum			x		x	x		3
Vollenhovia emeryi			x	x		x	x	3
Camponotus pennsylvanicus			x	x		x	x	2
Crematogaster pilosa			x	x		x		2
Amblyopone pallipes	x				x	x		1
Aphaenogaster tennesseensis			x	x		x		1
Camponotus castaneus			x	x		x	x	1
Camponotus nearticus			x	x		x	x	1
Lasius claviger	x				x	x		†
Camponotus subbarbatus	x		x	x		x		†
Lasius subumbratus	x			x		x		†
Myrmica emeryana	x			x		x	x	†

*Cavity includes spaces within twigs, fruits, fallen logs and branches, and any arboreal ant nests.
† These species are from the 2000-2001 study, and were not present in the 2002-2003 study.

abundance as the summer progressed during all 4 yr of these two studies (Fig. 3). Species with a lower abundance in the samples show less similar intraspecific abundances among years (Figs. 3-5). Few monthly abundance patterns can be detected in the other species besides a spike in abundance for some species such as *Aphaenogaster fulva*, *L. curvispinosus*, *P. pennsylvanica*, *Pyramica rostrata*, and *T. sessile* during August of most years (Figs. 3-5).

DISCUSSION

Ant Community of Dyke Marsh Preserve Forest

The ant community of DMP most closely resembled an urban forest and the hypothetical ant communities composed of the 31 more-common ant species (Table 4). The DMP forest is frequently disturbed by flooding from the Potomac River, and the ant community appears to be what would be expected for such a frequently disturbed forest. Ant species commonly found in relatively undisturbed second-growth forests nearby, such as *A. pallipes*, *A. fulva*, and *A. tennesseensis* are rare, and species common to fragmented and disturbed forests are common (Tables 1 and 2). The DMP ant community is composed of common species from eastern U.S. forest communities with only three exceptions: *L. subumbratus*, *S. molesta*, and *V. emeryi*. *Lasius subumbratus* in DMP is beyond its most southern previously known range on the East Coast (Wilson, 1955; Gregg, 1963) and is unlikely to be found in mid-Atlantic forests. The single record from the DMP may be a recent human introduction or a sign of new range expansion for this species.

Table 4. Coefficient of community similarity between the ant species of the Dyke Marsh Preserve, Virginia and other studies in the eastern United States.

Reference	Location	Habitat description	CC*	Species
King & Green 2005	Philadelphia County, PA†	Urban forests	0.52	38
Talbot 1934	Cook County, IL	Beech-maple, oak-maple old forests	0.49	24
Lynch et al. 1988	Allegany County, MD†	Floodplain forest	0.47	22
Lynch 1981	Anne Arundel County, MD†	Old forest, young forest, old fields	0.43	52
Carter 1962	Multiple Counties, NC†	Hardwood-bottomland forests	0.42	47
Lynch 1987	Anne Arundel County, MD†	Old and new forests and fields	0.41	62
Headley 1943	Ashtabula County, OH	Forests near Lake Erie	0.39	40
Wang et al. 2000	Augusta County, VA†	George Washington National Forest	0.35	27
Lynch 1981	Anne Arundel County, MD†	Sweetgum forest‡	0.35	15
Nuhn & Wright 1979	Durham County, NC†	Urban forests	0.34	28
Wang et al. 2000	Pocahontas County, WV	Monongahela National Forest	0.32	27
Cole 1940	TN and NC	Great Smoky Mountains National Park	0.25	66
Talbot 1965	Livingston County, MI	Low fields	0.23	28
Ellison et al. 2002	18 Counties, MA†	Bogs	0.22	25
Culver 1974	Greenbrier County, WV	Hardwood forest, old yard	0.20	17
More common species from all studies			0.59	31
More common species from all East Coast studies			0.55	31
Average number of species per study§				34.1

* CC = coefficient of community similarity

† U.S. East Coast Study

‡ The ants in this comparison are limited to those listed in this study's Sweetgum forest. The habitat of some species was not given in the relevant publication; therefore, this particular list may not be complete.

§ Average number of species does not include the two 31 more common species rows.

Solenopsis molesta, a common house-infesting ant, was found only in pitfall samples from one site on the edge of the southernmost part of the study forest. This ant may be more common upstream along the shoreline of the Potomac River which consists of manicured grass lawn for much of the area south of Washington, D.C. This tiny *Solenopsis* species (body length <1.5 mm), feeds on the brood of other ant species using underground galleries and is also a generalist forager in the litter layer (Creighton, 1950; Thompson, 1989). The subterranean foraging behavior of *S. molesta* could decrease the likelihood of capturing it in pitfall traps. However, no *S. molesta* were found in soil cores leading me to believe that its absence from samples is probably not sampling bias; rather *S. molesta* is not common in the DMP forest and may be occasionally entering the forest from more open habitats nearby (Lynch, 1987).

Vollenhovia emeryi is a recently discovered alien myrmicine ant from Japan, and appears to be spreading across the mid-Atlantic region (Kjar & Suman, 2007). The native range of this species spans the full length of the Japanese Islands (30-45° N), and thus it may have little problem acclimating from southern Virginia to southern New England along the U.S. East Coast. In its native habitat, this ant lives in very wet wood along riparian corridors (Kubota, 1984; Kinomura & Yamauchi, 1994).

Some species found in this study that are thought to be rare in eastern U.S. forests actually may be common but rarely caught. *Amblyopone pallipes, Proceratium silaceum, Pyramica ohioensis, and P. rostrata* have previously been regarded as uncommon and of low abundance when present. However, these species are unlikely to be observed or appear in trap samples due to their foraging behavior and nesting habits. *Amblyopone pallipes* has small nests of often less than 30 individuals, moves slowly, and feeds on centipedes. It lives in rotten logs or leaf litter. *Proceratium silaceum* also remains in the litter or within dead wood and is thought to prey on spider eggs. Both *Pyramica* spp. are highly modified, very small, litter-dwelling ants that feed on Collembola, small soft-bodied arthropods. Soil-core samples from the DMP had many *Pyramica* specimens, and these cryptic, slow-moving ants are apparently common in the Preserve's forest.

Although their populations may be large, all of these behaviors make these species less likely to be

Table 5. Frequencies of ant species from 16 lists and studies in the eastern and mid-eastern U.S. Species are arranged from most commonly reported through least commonly reported.

	Study*																
Species	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	Total
Aphaenogaster rudis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Ponera pennsylvanica	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Tapinoma sessile	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Lasius alienus	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	15
Temnothorax curvispinosus	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	15
Myrmica punctiventris	x	x		x	x	x	x	x	x	x	x	x	x		x	x	14
Myrmecina americana	x	x	x	x	x	x	x	x	x	x	x	x	x				13
Prenolepis imparis	x	x		x	x	x	x	x		x	x	x	x	x		x	13
Crematogaster lineolata		x	x		x	x	x	x		x		x	x	x	x	x	12
Lasius umbratus	x		x	x		x	x	x		x	x	x	x	x	x		12
Temnothorax longispinosus		x	x	x	x	x	x	x		x		x	x		x	x	12
Amblyopone pallipes	x	x	x	x	x	x	x	x		x		x		x			11
Aphaenogaster fulva	x	x	x	x	x	x	x	x			x		x			x	11
Brachymyrmex depilis	x	x	x	x	x	x	x	x		x			x	x			11
Camponotus pennsylvanicus	x	x	x			x	x	x		x		x	x		x		10
Camponotus subbarbatus	x	x	x		x	x	x		x	x	x	x					10
Camponotus chromaiodes	x	x			x	x	x	x		x		x	x				9
Lasius claviger	x	x	x		x	x	x	x					x				8
Camponotus americanus					x	x	x			x	x	x	x	x			8
Camponotus nearcticus	x	x			x	x	x						x	x	x		8
Crematogaster cerasi	x	x			x	x	x	x	x					x			8
Formica subsericea		x			x		x			x	x	x	x		x		8
Temnothorax schaumii		x		x	x		x	x		x		x	x				8
Monomorium minimum					x	x	x			x	x	x	x			x	8
Paratrechina faisonensis	x	x		x	x	x	x		x		x						8
Solenopsis molesta	x		x		x	x	x	x			x		x				8
Stenamma brevicorne	x	x	x				x			x		x		x	x		8
Dolichoderus plagiatus							x			x		x	x	x	x	x	7
Pyramica ohioensis	x			x	x	x	x		x		x						7
Pyramica rostrata	x	x		x	x	x	x				x						7
Aphaenogaster tennesseensis	x		x		x		x	x					x				6
Camponotus castaneus	x	x	x		x		x						x				6
Camponotus noveboracensis		x			x			x	x					x	x		6
Formica fusca						x		x					x	x	x	x	6
Formica pallidefulva					x	x	x	x					x	x			6
Lasius nearcticus		x	x					x		x		x	x				6
Lasius neoniger					x		x	x					x	x		x	6
Temnothorax ambiguus					x		x	x	x					x	x		6
Proceratium silaceum	x	x		x	x	x		x									6
Stenamma diecki		x		x	x		x						x			x	6
Stenamma impar	x	x		x	x		x		x								6
Aphaenogaster lamellidens						x	x				x		x			x	5
Aphaenogaster treatae					x	x	x				x		x				5
Dolichoderus pustulatus					x	x	x							x	x		5
Myrmica emeryana	x		x					x					x	x			5
Pyramica ornata				x	x	x	x				x						5
Crematogaster clara					x	x	x		x								4
Formica schaufussi					x	x	x						x				4
Harpogoxenus americanus					x		x	x			x						4
Pheidole dentata					x		x				x		x				4
Lasius interjectus		x											x			x	3
Crematogaster pilosa	x				x		x										3
Forelius pruinosus					x		x						x				3
Formica neogagates								x		x		x					3
Formica rubicunda			x					x					x				3
Formica subintegra							x	x					x				3
Lasius flavus		x											x	x			3
Lasius speculiventris											x			x	x		3
Temnothorax pergandei						x	x						x				3
Myrmica americana					x		x	x									3
Myrmica pinetorum		x								x		x					3
Tetramorium caespitum					x		x					x					3
Aphaenogaster carolinensis						x							x				2
Camponotus caryae								x					x				2
Crematogaster ashmeadi						x							x				2
Formica exsectoides								x					x				2
Formica integra					x		x										2

Table 5 (continued).

									Study[*]								
Species	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	Total
Formica nitidiventris										x		x					2
Formica obscuriventris										x		x					2
Myrmica fracticornis								x						x			2
Pheidole bicarinata					x		x										2
Pheidole davisii					x		x										2
Pheidole morrisi							x						x				2
Polyergus lucidus							x							x			2
Ponera trigona						x							x				2
Proceratium croceum							x						x				2
Proceratium pergandei		x											x				2
Pyramica clypeata		x			x												2
Pyramica dietrichi					x		x										2
Pyramica pergandei						x					x						2
Stenamma meridionale						x					x						2
Stenamma schmitti		x					x										2
Strumigenys louisianae						x					x						2
Vollenhovia emeryi	x	x															2
Lasius latipes							x										1
Aphaenogaster texana													x				1
Camponotus impressus				x													1
Camponotus mississippiensis						x											1
Crematogaster laeviuscula													x				1
Crematogaster missouriensis													x				1
Crematogaster vermiculata						x											1
Cryptopone gilva													x				1
Dolichoderus mariae														x			1
Dolichoderus taschenbergi													x				1
Dorymyrmex bureni													x				1
Dorymyrmex grand													x				1
Formica argentea															x		1
Formica cinerea			x														1
Formica habrogyn													x				1
Formica incerta								x									1
Formica lasioides														x			1
Formica neorufibarbis															x		1
Formica sanguinea													x				1
Hypoponera opaciceps							x										1
Hypoponera opacior						x											1
Hypoponera trigona					x												1
Lasius minutus														x			1
Lasius pallitarsis														x			1
Lasius subumbratus	x																1
Leptothorax acervorum								x									1
Temnothorax texanus						x											1
Monomorium pharaonis								x									1
Myrmica brevinodis			x														1
Myrmica incompleta															x		1
Myrmica lobifrons															x		1
Myrmica sculptilis															x		1
Myrmica smithana															x		1
Neivamyrmex carolinensis													x				1
Neivamyrmex nigrescens													x				1
Paratrechina flavipes		x															1
Pheidole crassicornis													x				1
Pheidole dentigula													x				1
Pheidole pilifera							x										1
Pheidole tysoni													x				1
Pheidole vinelandica													x				1
Pyramica creightoni													x				1
Pyramica pilansis											x						1
Pyramica talpa						x											1
Trachymyrmex septrionalis		x															1
Total (129 ant species)	31	39	24	22	52	47	62	40	15	27	28	27	65	28	25	17	

[*]Study: a, this study (low forest); b, King & Green 2005 (urban forest); c, Talbot 1934 (old forest); d, Lynch et al. 1988 (riparian forest); e, Lynch 1981 (old woods, old fields, new fields); f, Carter 1962 (low woods); g, Lynch 1987 (old woods, riparian woods, old fields, new fields); h, Headley 1943 (old woods); i, Lynch 1981 (old woods); j, Wang et al. 2000 (old woods); k, Nuhn & Wright 1979 (urban woods); l, Wang et al. 2000 (old woods); m, Cole 1940 (old woods, old fields); n, Talbot 1965 (low fields); o, Ellison et al. 2002 (low woods, bogs); p, Culver 1974 (old woods, old fields, new fields).

Table 6. Chao2 species-accumulation estimates for the study forest, Dyke Marsh Preserve, Virginia.

Sampling period and method	Chao2 species estimates Mean ± SD
2000-2003	
Both methods	31.5 ± 1.0
Pitfall traps	33.8 ± 3.0
2000-2001	
Pitfall traps	26.6 ± 3.9
2002-2003	
Both methods	28.4 ± 1.8
Pitfall traps	30.9 ± 3.6
Soil cores	16.3 ± 2.2

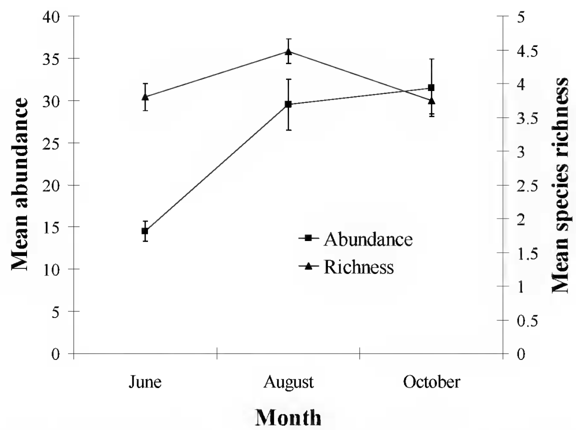

Fig. 1. Mean ant abundance and species richness in pitfall and soil-core samples at Dyke Marsh Preserve, Virginia, 2002-2003. Error bars are ± 1 standard error.

captured in pitfall traps. *Pyramica* spp. may have nests of at least 50 individuals in DMP (pers. obs.), yet they are distinctly under-represented in pitfall traps, particularly compared to soil cores in this study. Myrmecologists previously thought *Pyramica* spp. were rare, but with the increasing use of Winkler extraction of leaf litter and Berlese extraction of soil cores, these cryptic ants appear to be much more abundant and common world-wide (Bolton, 2000). *Brachymyrmex depilis* is another species with large colonies, and competes with *Lasius* and other common genera. I encountered it only once in pitfall trapping, but soil cores produced 26 specimens. These results agree with earlier work in the mid-Atlantic region that found *B. depilis* to be present predominately in soil and rarely found in the litter layer (Lynch et al., 1988).

The majority of ant species found in DMP are native and common in riparian forests in the mid-Atlantic region (Lynch et al., 1988; Table 3). A notable absence from the DMP forest is *Paratrechina flavipes*. This alien ant from Asia has displaced the native *P. faisonensis* in much of Rock Creek Park in Washington, D.C. (Stefan P. Cover, pers. comm.), but has apparently not reached the DMP or is rare in it. Several of the species found in the DMP forest are common around human habitations, including *L. alienus*, *P. imparis*, *S. molesta*, and particularly *T. sessile*. *Lasius alienus*, *P. imparis*, and *T. sessile* are competitive surface foragers and common in most areas of the U.S. All three are generalists with large colonies and may tend homopterans.

The Chao2 species estimator predicted 31.5 ant species in the DMP study forest, and the fact that *Lasius subumbratus* remains the only singleton after 4 yr of trapping, both lend support to the thoroughness of my ant survey (Tables 2 and 6). Although other methods of trapping and hand sampling may reveal more species, the combination of soil cores and pitfall traps, the number of sampling events (680 pitfalls, 360 soil cores), and the wide range of areas sampled within this small forest make it likely that all of the forest ant species are represented in my trap samples.

Temporal Distribution of Ant Species

Previous studies have examined the competitive interactions of common eastern ant species, in particular *P. imparis*, *P. faisonensis*, and *A. rudis* (Lynch et al., 1980; Fellers, 1987, 1989). These authors hypothesized that competition may be reduced in this ant group if each species forages at different times of the year. My results show that the sample catches of the common and abundant species are similar from year to year, and behave as previously reported in similar ant communities (Lynch et al., 1980; Fellers, 1989; Fig. 2). The abundance of *Aphaenogaster rudis* and *P. faisonensis* peaked during August and declined during October as *P. imparis* numbers rapidly increased (Fig. 2). *Prenolepis imparis* forages throughout the cold season in the mid-Atlantic region when temperatures are above freezing (pers. obs.). This is a competitive species which displaces *A. rudis* and *P. faisonensis* from baits (Lynch et al., 1980). However, whether or not the changes in ant abundance are a response to competition is debatable, and the results of this study only add another example of the predictability of this previously observed relationship. The decrease in *A. rudis* and *P. faisonensis* may be a result of competition with *P. imparis*, reduced activity due to declining temperatures, or both. The intraspecific abundances of less abundant ant species were not predictable from year to year. Overall, ant abundance in samples increased and ant species richness decreased in October (Figs. 3-5). The

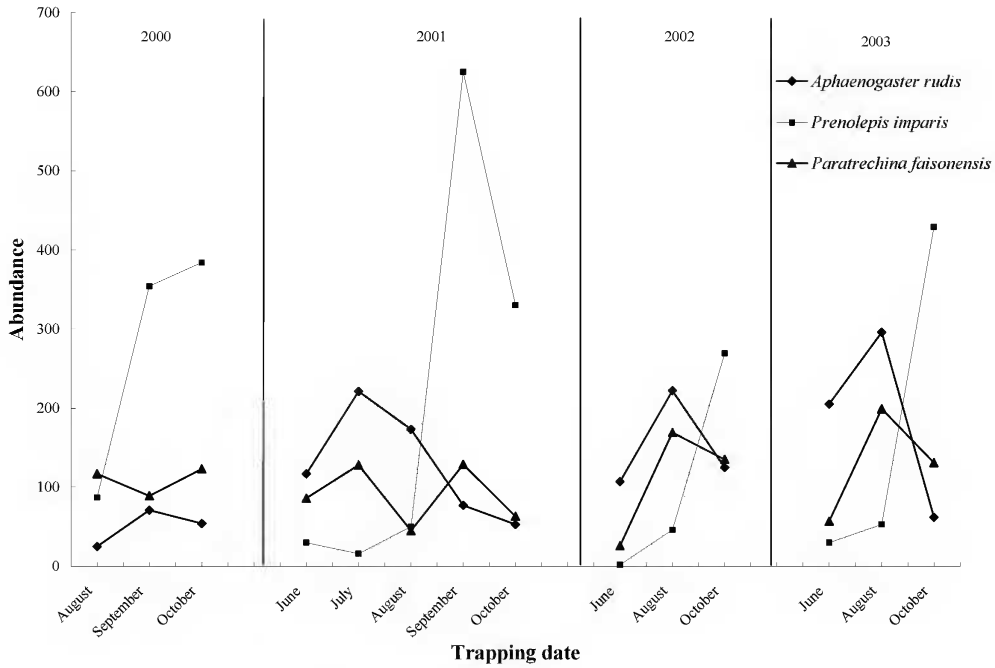

Fig. 2. Abundance of the three more abundant ant species in pitfall and soil-core samples for the years 2000-2003, Dyke Marsh Preserve, Virginia.

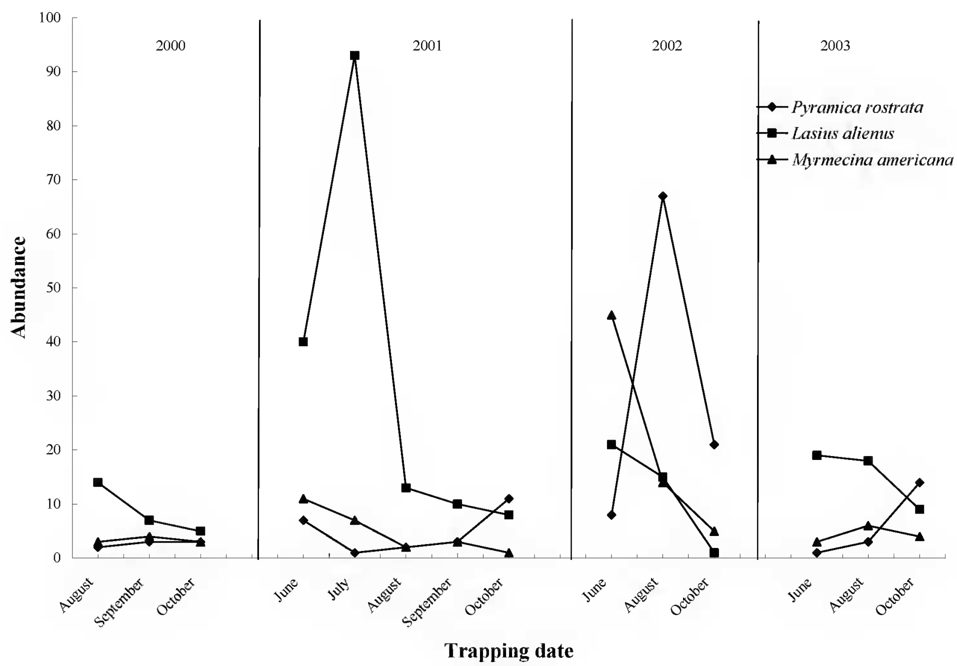

Fig. 3. Abundance of three ant species of lower abundance in pitfall-trap and soil-core samples for the years 2000-2003, Dyke Marsh Preserve, Virginia.

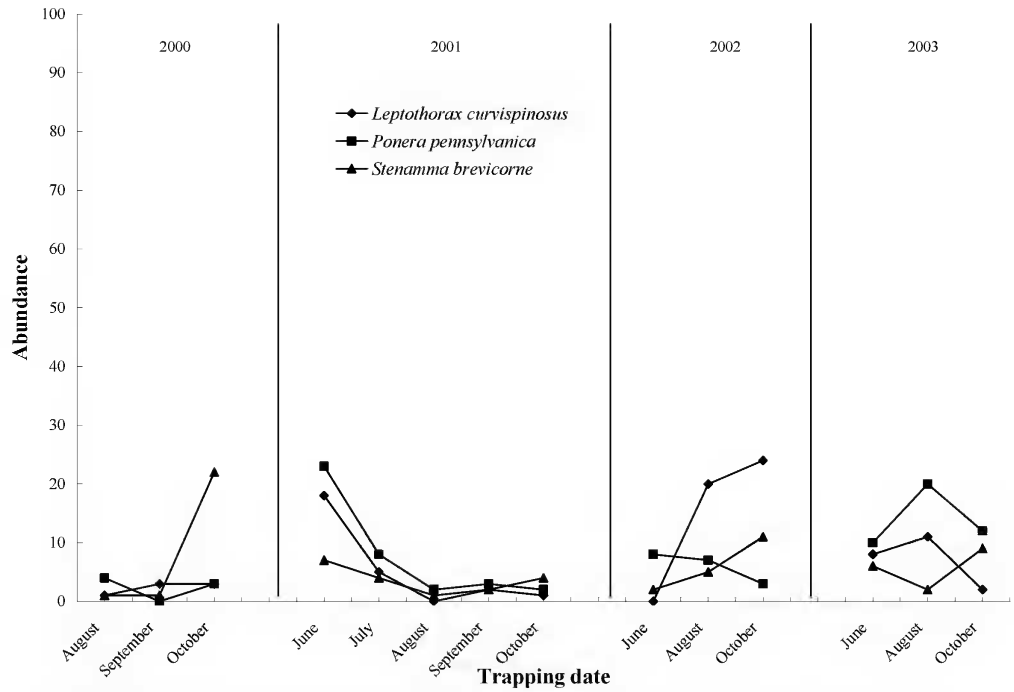

Fig. 4. Abundance of three ant species of lower abundance in pitfall-trap and soil-core samples for the years 2000-2003, Dyke Marsh Preserve, Virginia.

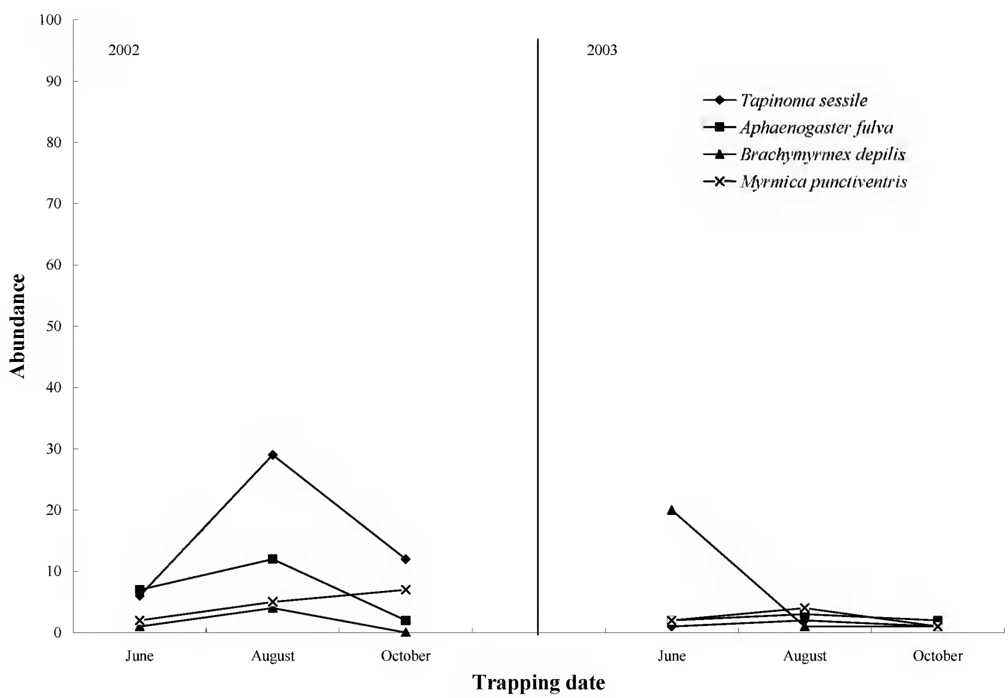

Fig. 5. Abundance of four ant species in pitfall and soil-core samples that were not present in the 2000-2001 study, Dyke Marsh Preserve, Virginia.

decrease in total ant richness may be the result of competition with *P. imparis* or more likely decreasing foraging activity as daily temperatures approach freezing at night (Fig. 1).

CONCLUSIONS

Pitfall-trap and soil-core samples yielded 3,193 ants of 27 species. Inclusion of an earlier study from this riparian forest adds four species. The ant community has many common eastern forest species; one not common to this region, *L. subumbratus*; and the introduced Japanese ant *V. emeryi*. Variation in trap samples across months shows that the most abundant species in trap samples, *P. imparis*, peaks in abundance during early fall. *Aphaenogaster rudis* and *P. faisonensis* have higher incidences in trap samples than all other ant species. Ant species richness in the DMP study forest was highest in August, while abundance was highest in October. The ant community of this small forest within DMP is now relatively well known, and the ant community of other areas in the Preserve should be examined as they may contain different and important ant species. To understand the importance of the unique habitats in the Preserve on the ant community better, trapping and hand collecting should be conducted in other forested parts of the Preserve, the ecotone between the forest and the marsh, the marsh, and along the many shorelines.

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